

Radioscapholunate Fusion for Radiocarpal Osteoarthritis: Prognostic Factors of Clinical and Radiographic Outcomes

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Abstract

Background Radioscapholunate (RSL) fusion is a surgical option to manage radiocarpal osteoarthritis. Many authors upgrade the procedure by adding distal scaphoid excision with or without excision of the triquetrum. Our objective was to identify the prognostic factors for good clinical and radiographic outcomes of RSL arthrodesis.

Purpose Distal scaphoid excision improves both scaphotrapeziotrapezoidal osteoarthritis and radiocarpal fusion, and excision of the triquetrum is not critical to achieving satisfactory outcomes.

Methods In this retrospective and bicentric investigation, all wrists were managed with RSL fusion for posttraumatic radiocarpal osteoarthritis. A total of 85 patients were included and evaluated at the revision by clinical (pain, wrist motion, and strength), functional (Disabilities of the Arm, Shoulder, and Hand questionnaire, Patient-Related Wrist Evaluation score, and Modified Mayo Wrist Score), and radiological (scaphotrapeziotrapezoidal, midcarpal osteoarthritis, and radiocarpal nonunion) examinations. We assessed prognostic factors for clinical and radiographic (osteoarthritis and nonunions) outcomes.

Results The average follow-up was 9.1 years (1–21.4). Work-related accidents adversely impacted the clinical outcomes, and distal scaphoid excision significantly improved them and decreased scaphotrapeziotrapezoidal osteoarthritis and nonunion. Neither distal scaphoid excision nor excision of the triquetrum influenced midcarpal osteoarthritis. Radiocarpal fusion was significantly promoted by memory staples and bone grafting.

Discussion Distal scaphoid excision should be preferred to improve the functional results while decreasing scaphotrapeziotrapezoidal osteoarthritis and radiocarpal nonunion rates. Excision of the triquetrum appears to be an alternative to radioulnar resection–arthroplasty to solve ulnocarpal impaction syndrome. Strict surgical procedure must be observed to promote RSL fusion combining solid bone fixation and the use of bone graft.

Level of evidence This is a level IV, case series, retrospective series.

Keywords

- arthrodesis
- fusion
- radioscapholunate
- radiocarpal
- arthritis
- prognostic factor

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A range of surgical procedures has been described to manage radiocarpal osteoarthritis (OA). Wrist denervation is safe and effective but provides inconsistent results.^{1,2} Wrist arthroplasties have yielded very poor medium-term results and a high rate of complications, compelling surgeons to use this procedure with caution in young patients.³ Total wrist fusion (TWF) ensures a stable and painless wrist but prevents all motion.⁴ Last, partial wrist fusion, although expected to provide pain relief while preserving motion, requires the midcarpal joint to be free of OA.^{5,6} Depending on the localization of the OA, radioscapholunate (RSL), radiolunate, and radioscaphoid fusions have been described. As the entire radiocarpal joint is frequently damaged, RSL fusion remains the most common surgical option to manage radiocarpal OA.^{5,7}

Despite the reports of early favorable clinical outcomes, long-term series after RSL fusions have emphasized limited wrist motion with high complication rates.^{8,9} Nonunion rates range from 0 to 29%, whereas midcarpal OA rates from 0 to 100%.^{8–12} Given those complications and the restricted motion after RSL fusion, many authors have modified the procedure by adding distal scaphoid excision (DSE, i.e., excision of the distal pole of the scaphoid) to improve motion in flexion and radial deviation while decreasing scaphotrapeziotrapezoidal (STT) OA.^{8,10,13–15} Likewise, excision of the triquetrum (ET) has been proposed to improve motion in extension and ulnar deviation while removing the ulnocarpal impaction.^{10,13}

To date, no study has investigated the prognostic factors for achieving good clinical or radiographic outcomes after RSL fusion. We hypothesized that DSE improves both STT OA and radiocarpal fusion and that ET is not critical to achieving satisfactory outcomes.

The primary objective of this study was thus to identify the prognostic factors for good clinical and radiographic outcomes of RSL arthrodesis after wrist trauma. The secondary objective was to assess the correlation between good clinical and radiographic outcomes.

Methods

From 1995 to 2015, 85 patients (74 males and 11 females) with a mean age of 43 years (18–70) who underwent RSL arthrodesis in two university hospitals were retrospectively included. The indications for surgery were a painful post-traumatic wrist OA interfering with daily living activities and resistant to conservative treatment. Inflammatory and Kienbock's diseases were excluded from this series. Clinical and radiographic evaluations were performed at revision by an independent examiner at the last follow-up. The study was approved by the Institutional Ethics Committee, and patients' written consent was systematically obtained.

Surgical Technique

A midline dorsal approach was used. The first step of the procedure was to inspect the midcarpal joint to ensure it was not damaged. The articular surfaces of the radiocarpal joint were then denuded of cartilage to the subchondral bone using osteotomes. The scapholunate joint was temporarily fixed in anatomical alignment with a Kirschner wire (K-wire).

Depending on the surgeon, the surgical technicalities differed somewhat. For example, bone grafts were either cancellous grafts from the distal radius or proximal ulna or grafts from the corticocancellous iliac crest. DSE alone or in association with ET was performed with the same dorsal approach (►Fig. 1). Fixation was achieved with a locking T-plate, screws and/or memory staples, and/or K-wires. Ulnar head resection (Darrach's procedure) was performed for distal radioulnar dislocation or OA. All wrists were immobilized with a forearm cast for a mean period of 6.7 weeks (2–14).

Demographic Factors

We assessed patients' age at procedure, sex, manual labor, workplace injury, and dominant wrist affected.

Clinical Evaluation

Pain was assessed with a visual analog scale (VAS; 0–10) at rest and during daily living activities. Global mean pain therefore included both rest and activity scores. The active range of wrist motion in flexion, extension, and radial and ulnar deviation was assessed with a standard goniometer. Grip strength was averaged over three consecutive measurements using the Jamar hydraulic hand dynamometer. Functional status evaluation included the short version of the Disabilities of the Arm, Shoulder, and Hand questionnaire (QuickDASH), Patient-Related Wrist Evaluation score (PRWE), and Modified Mayo Wrist Score (MMWS).

Radiographic Records

Radiological analysis was performed by assessing strict anteroposterior and lateral X-rays. At the last follow-up, we assessed radiocarpal fusion and degenerative OA. Fusion was described as achieved when clear trabecular bone could be seen crossing from the radius to the carpus, as described by Bain et al.¹³ Degenerative changes were determined by joint space narrowing, localized subcortical sclerotic changes, osteophytes, and/or subchondral cysts. Degenerative changes were described as affecting the STT joint or the midcarpal joint (scaphocapitate, lunocapitate, and/or triquetrohamate).

Statistical Analysis

We separated the assessment of prognostic factors for good clinical outcome and good radiographic outcome after RSL. The assessment of clinical outcome was based on Cooney et al's classification,¹⁶ with a good outcome corresponding to the classification's definition of good and excellent results after fracture–dislocation of the wrist (►Table 1). Patients who underwent TWF were considered as having poor clinical outcomes.

We also assessed prognostic factors for OA in both the STT and midcarpal joints, as well as for radiocarpal nonunions.

Statistical analysis was performed using SPSS 23.0 (IBM, Armonk, North Castle, NY). Categorical variables were expressed as numbers and percentages and were compared between groups using the chi-square test. The normal distribution of the quantitative variables was tested with the Shapiro test. Continuous data were presented with means and standard deviations (SD). Comparisons between the groups

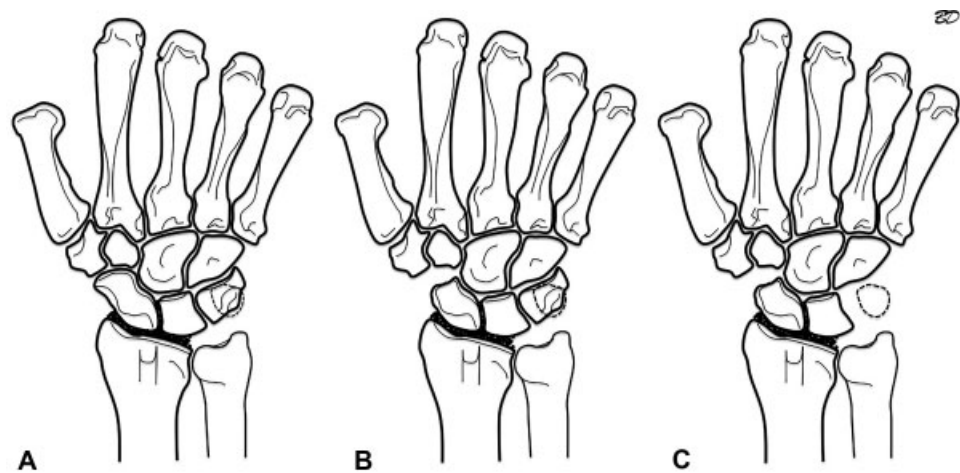


Fig. 1 Radioscapholunate fusion alone (A), with distal scaphoid excision (B), and with both distal scaphoid excision and excision of the triquetrum (C).

Table 1 Modification of Cooney’s classification¹⁶ into good or poor clinical outcome after the procedure

	Good clinical result	Poor clinical result
Global pain	None or slight (VAS ≤ 3)	Moderate or severe (VAS > 3)
Wrist motion	Functional motion (all needed): Flexion ≥ 5 degrees Extension ≥ 30 degrees Radial deviation ≥ 10 degrees Ulnar deviation ≥ 15 degrees	Nonfunctional motion in at least one direction
Grip strength (% of contralateral side)	≥50%	<50%

Abbreviation: VAS, visual analog scale.

were made using Student’s *t*-test. Correlations between groups were investigated using Spearman’s test and expressed with the rho coefficient (*r*). Multivariate analysis was conducted through logistic regression models. The significance threshold was set at *p* < 0.05.

Results

Before the final follow-up, 10 (12%) patients were lost to follow-up and 11 (13%) patients underwent TWF for early midcarpal OA. Thus, we included 75 patients for an average follow-up of 9.1 years (1–21.4): 33 RSL fusion alone, 26 RSL fusion with DSE, and 16 RSL fusion with both DSE and ET. Twenty-two ulnar head resections were performed.

Clinical Outcome

Of the 75 patients, 25 (33%) had overall good clinical outcomes. Forty-one (55%) fit the pain criterion for a good outcome, 34 (45%) fit the wrist motion criterion, and 48 (64%) fit the strength criterion. The three criteria were significantly correlated with each other (*p* < 0.05). Patients achieving good clinical outcome had significantly better functional scores compared with other for QuickDASH (30.8 vs. 44.; *p* = 0.019), PRWE (28.3 vs. 41.9; *p* = 0.017), and MMWS (79.6 vs. 59.5; *p* < 0.001).

Clinical outcomes, but not other patient characteristics, were adversely impacted when the injury was work-related

(*p* = 0.008). DSE enhanced the clinical outcome (*p* = 0.0031; ►Table 2). Neither bone grafting nor the type of fixation influenced clinical outcome (*p* > 0.05).

Scaphotrapeziotrapezoidal Osteoarthritis

STT OA was noted in 24 (32%) patients. No patient characteristic, bone graft, or fixation mode had an impact on STT OA (*p* > 0.05). DSE drastically decreased the STT OA rate (*p* < 0.001; ►Table 3). STT OA was described in 3 (7%) out of 42 patients after DSE vs. 21 (64%) out of 33 when it was not performed (*p* < 0.001).

Midcarpal Osteoarthritis

Midcarpal OA was found in 33 (44%) patients. These patients (►Fig. 2) were significantly older than those without midcarpal OA at the time of the procedure (48.3 vs. 40.3 years; *p* < 0.0053). Affection of the dominant side influenced the development of midcarpal OA (73% vs. 48% of dominant wrist affection; *p* = 0.028). No other patient characteristic, bone graft, or fixation mode influenced midcarpal OA (*p* > 0.05).

Midcarpal OA was noted in 17 (41%) out of 42 patients with DSE versus 16 (48%) out of 33 without it (*p* = 0.289). Neither DSE nor ET influenced midcarpal OA (►Table 4).

Radiocarpal Nonunion

Complete radiocarpal fusion was achieved in 57 (76%) patients. These patients were significantly younger at the

Table 2 Clinical outcome (number and percentage) according to surgical technicalities

	Good clinical outcome (n = 25)	Poor clinical outcome (n = 50)	p-Value
Distal scaphoid excision (n = 42)	20 (80)	22 (44)	0.0031
Excision of the triquetrum (n = 16)	7 (28)	9 (28)	0.564
DRUJ arthroplasty (n = 22)	9 (36)	13 (26)	0.370
Immobilization period (weeks)	7.0 (3–14)	6.7 (3–12)	0.571

Abbreviation: DRUJ, distal radioulnar joint.
Note: significant value is presented in bold.

Table 3 STT OA according to surgical technicalities and radiographic outcome (number and percentage)

	STT OA (n = 24)	No STT OA (n = 51)	p-Value
Distal scaphoid excision (n = 42)	3 (12)	39 (76)	<0.001
Excision of the triquetrum (n = 16)	2 (8)	14 (27)	0.0593
DRUJ arthroplasty (n = 22)	7 (29)	15 (29)	0.928

Abbreviations: DRUJ, distal radioulnar joint; OA, osteoarthritis; STT, scaphotrapeziotrapezoidal.
Note: significant value is presented in bold.

**Fig. 2** Radiograph of radioscapholunate fusion with distal scaphoid excision and midcarpal osteoarthritis (A) and without distal scaphoid excision and radioscaphoid nonunion and midcarpal osteoarthritis (B).

time of the procedure than those who developed nonunion (42.3 vs. 48.8 years; $p = 0.0406$). No other patient characteristic influenced nonunion ($p > 0.05$).

Fusion was significantly promoted by the use of memory staples ($p = 0.0139$) and bone grafting ($p = 0.0051$), but the

Table 4 Midcarpal OA according to surgical technicalities (number and percentage)

	Midcarpal OA (n = 33)	No midcarpal OA (n = 42)	p-Value
Distal scaphoid excision (n = 42)	17 (51)	25 (59)	0.489
Excision of the triquetrum (n = 16)	9 (27)	7 (17)	0.266
DRUJ arthroplasty (n = 22)	9 (27)	13 (31)	0.728

Abbreviations: DRUJ, distal radioulnar joint; OA, osteoarthritis.

choice between the two types of graft had no significant influence (►Table 5). DSE significantly reduced radiocarpal nonunion ($p < 0.0041$, ►Fig. 2). Only 4 (9%) patients out of 42 with DSE did not achieve fusion versus 14 (42%) out of 33 without DSE. ET did not influence fusion.

Correlation between Series Criteria

Clinical outcome was significantly correlated with the absence of midcarpal OA ($r = 0.285$; $p = 0.013$). The midcarpal OA rate was 24% for patients with good clinical outcomes ($n = 6$; ►Fig. 3) versus 54% for those with poor clinical outcomes ($n = 27$). No other correlations were noted.

Discussion

According to the literature, residual motion after RSL fusion is sufficient to cover most regular functional demands.^{9,17,18} We believe that even when functional motion, as described by Palmer et al,¹⁹ is achieved, a painful or weak wrist should not be considered as functional. We followed the classification of Cooney et al to evaluate the clinical results and combined three clinical criteria: pain, wrist motion, and grip strength.¹⁶ All criteria were significantly correlated with each other, and the functional scores were significantly better in patients with good clinical outcomes, strengthening our idea to combine them.

The importance of dart thrower's motion, which consists of an everyday movement along an oblique direction from radial extension to ulnar flexion, has been emphasized in the literature and occurs mainly in the midcarpal joint.^{20–22} Thus, RSL fusion enables dart thrower's motion. Garcia-Elias et al pointed out that although radiocarpal fusion may result in less motion than intercarpal arthrodesis, it nevertheless provides a much more natural and efficient wrist motion.⁷ Therefore, from a functional standpoint, and although it limits wrist motion, RSL procedures are not necessarily functionally detrimental.

Clinical outcomes were adversely influenced when the injuries were work-related, although no other patient characteristic had an impact. Workplace injury has been clearly emphasized in the literature as a poor prognostic factor for

Table 5 Radiocarpal nonunion (number and percentage) according to surgical technicalities

		Radiocarpal nonunion (n = 18)	Radiocarpal fusion (n = 57)	p-Value
Fixation mode	Staples	8 (44)	43 (75)	0.0139
	Screws	7 (39)	30 (53)	0.309
	Locking plates	3 (17)	8 (14)	0.719
	Kirschner wires	6 (33)	8 (14)	0.0670
Bone graft	None	10 (56)	12 (21)	0.0051
	Cancellous graft	7 (39)	37 (65)	0.0934
	Corticocancellous iliac crest bone	1 (5)	17 (30)	0.0547
Distal scaphoid excision (n = 42)		4 (22)	38 (67)	0.0041
Excision of the triquetrum (n = 16)		3 (17)	13 (23)	0.729
DRUJ arthroplasty (n = 22)		3 (17)	19 (33)	0.240

Abbreviation: DRUJ, distal radioulnar joint.
Note: significant values are presented in bold.



Fig. 3 Radioscapholunate fusion with distal scaphoid excision on strict anteroposterior (A) and profile (B) X-rays at 6.8 years of follow-up, with complete fusion and no signs of midcarpal osteoarthritis. The patients achieved good clinical outcomes with slight pain (global visual analog scale = 1/10), functional wrist motion, and grip strength measured at 80% to the contralateral side.

clinical results and the return to work.²³ Although it is an unalterable aspect of the patient characteristics, surgeons should be aware that the clinical result will be negatively affected. DSE significantly improved clinical outcomes in our series. Several authors reported this finding but not always provided the results on pain or strength.^{10,14,15}

The global OA rate after RSL fusion ranges from 0 to 100% in the literature,^{8–12} but several series did not distinguish the involved joint: STT or midcarpal (e.g., scaphocapitate, lunocapitate, or triquetrohamate). Although the STT joint anatomically belongs to the midcarpal joint, we separated the two localizations of OA because their origins are different. In this study, patient characteristics did not influence STT OA changes, but patient age and affection of the dominant wrist significantly impacted midcarpal OA.

The main explanation for STT OA after RSL fusion concerns the mechanical strain between the scaphoid and the distal

row. As the scaphoid is fixed to the radius, wrist movements in flexion or radial deviation increase the stress on the STT joint.²⁴ Thus, DSE can delay the constraints on the STT joint, unlock the midcarpal joint, and decrease the development of OA.^{6,14,25} In agreement with the literature, our results showed that DSE significantly reduced STT OA.^{8,10,13–15,26} We described three cases of STT OA despite DSE and suspected that the procedure was secondary to an incomplete excision.

The origins of midcarpal OA are not well known: it might ensue from cartilage damage during the initial injury or be secondary to RSL fusion. All authors have emphasized the importance of midcarpal inspection during the procedure.^{5–7} The orthopaedic literature has described that the loss of motion at the fusion site overloads the adjacent joints.^{24,27} These altered joint kinematics adjacent to the fusion site may cause mechanical strains that could lead to cartilage damage. Likewise, midcarpal incongruence due to inappropriate bone fixation can lead to abnormal loading and subsequent midcarpal OA.^{5–7}

Holleran et al found that increased contact pressure on the lunocapitate joint caused by DSE may enhance the incidence of midcarpal arthritis.²⁸ Although the authors did not assess pressure after additional ET, such pressures would probably be further increased. Bain et al described pristine midcarpal joint after performing RSL fusion with DSE and ET in all 23 patients at an average follow-up of 2.6 years.¹³ Conversely, Ha et al compared the long-term results (mean: 14.8 years) of RSL fusion with and without DSE and ET.¹⁰ The lunocapitate joint spaces were narrower in patients with RSL fusion, DSE, and ET compared with the others. Midcarpal joint spaces were noted to be similar in patients with RSL fusion with or without DSE, and the literature contains no reports on excessive midcarpal degenerative changes after RSL and DSE (– Table 6). Although we found no statistical impact of ET on midcarpal OA, we strongly suspect that excising the entire triquetrum is an alternative to radioulnar resection–arthroplasty to solve ulnocarpal impaction syndrome. In this context and by extrapolating Holleran’s results, we would prefer performing Darrach’s procedure especially because it does not influence clinical or radiographic result.

Table 6 Midcarpal OA and nonunion rates (number and percentage) after radioscapholunate fusion and distal scaphoid excision in the literature

	Number of cases ^a	Follow-up (years)	Midcarpal OA	Nonunion
Garcia-Elias et al ¹⁴	16	3.1	2 (13)	0
Bain et al ¹³	23	2.6	NR	0
Mühdorfer-Fodor et al ¹⁵	20	2.3	6 (30)	0
Quadlbauer et al ²⁶	14	5.3	0	0
Montoya-Faivre et al ⁸	19	4.4	7 (37)	4 (21)
Ha et al ¹⁰	11	14.8	NR	0
Our series	42	9.2	14 (33)	4 (9)

Abbreviation: NR: nonreported; OA, osteoarthritis.

^aThe number of cases for each series represents the number of patients with distal scaphoid excision (with or without excision of the triquetrum) and may be different from the series' total cohort.

The nonunion rate after RSL fusion has ranged from 0 to 29%, depending on the series.^{8–10,13,15,26} This worrisome rate may have several explanations. First, technical errors could have resulted in a lack of bone fixation, especially K-wire, in most of the older series. Most authors have highlighted the importance of good compression to achieve fusion by using a locking plate or memory staples.^{13,18,26}

The use of memory staples significantly promoted fusion. We found no evidence for compression screws or locking plates, but we routinely use them as they ensure solid bone fixation. K-wire should be used only in association with bone screws or memory staples.

Bone grafting significantly promoted fusion. However, we did not find statistical evidence regarding the type of bone graft (cancellous or corticocancellous iliac crest bone grafts). Thus, we strongly recommend the use of at least cancellous bone grafting during the procedure.

In our series, DSE strongly promoted radiocarpal fusion. An analysis of the literature revealed only 4 (4%) cases of nonunion from among 103 patients (► **Table 6**).^{8,10,13–15,26} Garcia-Elias et al reported that the lengthening of the lever arm due to fusion increased the stresses transmitted from the distal radius to the scaphoid and, thus, could promote nonunion.¹⁴

We note several limitations of this series. This was a retrospective study conducted in two university hospitals and managed by multiple different surgeons. We did not include extrinsic factors such as smoking or previous corticosteroid therapy in this series because they were not reported in the patients' clinical records, although these factors might have promoted nonunion. The literature review revealed a huge gap between series in the assessment of midcarpal OA. Further investigations, ideally using computed tomography (CT) scan evaluation, are required to clarify the long-term impact of both DSE and ET on the midcarpal joint.

Conclusion

RSL fusion is a reliable surgical procedure to manage post-traumatic radiocarpal OA. Around half the series achieved functional wrist motion. Workplace injury adversely affected the clinical outcome.

We recommend additional DSE to improve both clinical and radiographic results. This will promote complete fusion and avoid STT OA.

In the case of ulnocarpal impaction syndrome, both ET and radioulnar resection–arthroplasty can be performed. Although we did not find any evidence of increased midcarpal OA after ET, our experience has led us to prefer radioulnar resection–arthroplasty using Darrach's procedure.

Strict surgical procedure must be observed to promote RSL fusion. We recommend the use of memory staples in association with screws to achieve maximal bone compression. Likewise, we advise bone grafting using corticocancellous iliac crest bone or at least a radial cancellous graft.

Note

The study was approved by the Institutional Review Board and patients' written consent was systematically obtained.

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Conflict of Interest

Dr. Coulet reports personal fees from Exactech France, outside the submitted work. Dr. Dap reports nonfinancial support from Groupe Lepine, outside the submitted work. Dr. Dautel reports nonfinancial support from Stryker, outside the submitted work. Dr. Chammas reports personal fees from Zimmer Biomet, Zimmer Biomet, outside the submitted work.

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